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EMBRYOLOGY.<sup>1</sup>**Morphology of the Vertebrate Urino-genital System.—**

From a detailed study of the excretory and reproductive organs of *Ichthyophis glutinosus*, one of the Cæcilians, Professor Semon, of Jena, is led to a conception of the vertebrate urino-genital system containing many points of interest and importance.

The material used consisted of embryos, larvæ and adults obtained in Ceylon by P. and F. Sarasin, and is fully described in the first sixty pages of text with the aid of fourteen plates.

Passing on to the comparative discussion of the results obtained, illustrated by diagrams, we may first give the chief facts observed by the author and then some of his applications of these to the morphology of the excretory and reproductive organs in the entire vertebrate groups.

The pronephros consists of at least twelve pairs of tubes, one pair in each segment, opening into two pronephric ducts that run to the cloaca and opening at the other end by funnels into the body cavity. The dorsal part of the body cavity receiving these twelve pairs of funnels is constricted off as a tube on each side, remaining, however, still in communication with the large ventral part of the coelom by slender tubes that become secondary funnels. These tubes next appear as branches of the original pronephric tubules, each of which now has two funnels, a ventral and a dorsal one. The dorsal tube of coelom is then partly divided by ingrowths of vascular loops, glomeruli, into chambers, one for each dorsal funnel. These chambers are the Malpighian bodies of the pronephros. Irregularities appear in the branching and connections of the pronephric tubules both anteriorly and posteriorly in this long series; finally secondary changes occur and the organ loses its function. Before this takes place the mesonephros appears and both function at the same time. Though chiefly posterior to the pronephros the mesonephros also extends forward so that both organs occur in the same segment. Then it is seen that the mesonephros is dorsal to the pronephros. At the very first the mesonephric tubules are strictly segmental, but very soon the secondary, tertiary, etc., tubules destroy the metameric arrangement. Each tubule has a funnel opening into the large coelom and also opens by what may be regarded as a second funnel into the Malpighian capsule. These meso-

<sup>1</sup>This department is edited by Dr. E. A. Andrews, Johns Hopkins University.

nephric Malpighian capsules may be regarded as parts of the coelom pinched off segmentally, much as those of the pronephros were. The coelom has thus given rise to two series of dorsal diverticulæ, Malpighian capsules, which remain connected with the ventral coelom by tubes with funnels, while their openings into the other nephric tubules are regarded as another primary set of funnels.

The pronephric duct serves also for the mesonephros and the two organs are also connected in another way: each segmental Malpighian capsule of the mesonephros is connected with a longitudinal cord of epithelial cells by means of a similar but more simple transverse cord. This longitudinal cord, on each side of the body, runs back to the cloacal region and is continuous anteriorly with the series of pronephric Malpighian capsules; in fact as the latter degenerate they become incorporated with the anterior end of this cord. The cord is thus a sort of degenerated remnant of a longitudinal coelom tube connected with the pronephric tubules and by solid cords with the mesonephric Malpighian capsules. This degenerate structure is that part of the adrenal body distinguished as the interrenal body of each side.

The Müllerian duct arises dorsal to the nephros and without any connection with the pronephric duct.

The free ventral part of the germinal fold becomes the fat body, some of the dorsal part the germinal epithelium. This germinal epithelium is ventral to the nephros and connected by a loose meshwork of epithelial cords with those similar cords connecting the primary mesonephric Malpighian capsules with the interrenal body. This network disappears in the female but remains, in part, in the male as the tubules conveying the sperm to the kidney. The reproductive gland is not segmentally divided nor are the anastomosing cords going to the kidney.

In applying these facts to the understanding of the urino-genital organs of vertebrates past and present the author regards *Ichthyophis* as presenting many ancestral traits.

Thus the primitive urino-genital system of the Craniata consisted of pronephros and germinal ridges extending from the region of the heart to the cloaca. The germinal cells discharged into the unsegmented dorsal part of the coelom were taken up by the segmental funnels of the pronephros. Later this dorsal coelomic space became pinched off, except for the connecting external funnels of the pronephros, and by ingrowth of glomeruli was converted into a series of Malpighian capsules. Still the reproductive cells pass into these capsules by tubes that elongate as the capsules become more deeply retro-peritoneal.

Finally, in the stage to which all Craniata attain at the present day, a second generation of tubules, the mesonephric tubules, is cut off from the primary pronephric tubules, while the Malpighian capsules divide into dorsal and ventral parts. Into the first open the new mesonephric, into the ventral the primary pronephric tubules, each by its internal funnel, while its external funnel opens into the general coelom. The appearance of this dorsal mesonephros is accompanied by a reduction and transformation of the pronephros, combined with sympathetic ganglia (suprarenal bodies) to form the adrenal body. The reproductive cells must now pass out by the new mesonephric tubules to the pronephric duct.

In male vertebrates there is in addition a reduction of the germinal epithelium to a short portion of its primitive length and a corresponding restriction of the connection of testis and nephros. This leads to the distinction between "sexual" nephros and the more posterior "pelvic" nephros, which is finally quite separated in the higher forms as the *metanephros* or true kidney.

The complete separation of testis and excretory organs in the teleosts and cyclostomes is to be regarded as secondary.

In the female, secondary changes, perhaps connected with increase in size of the ova, have led to the restriction of the egg-conducting function of the pronephros to a single tubule, which then opened into a secondary duct, the Müllerian duct, divided off from the pronephric duct. For the understanding of the true value of the peritoneal opening of the Müllerian duct and for any satisfactory homologizing of the oviducts of teleosts we must await further researches upon these organs in the ganoids.

True abdominal pores, serving for exit of the reproductive products in Cyclostomes but not in any Gnathostomes, are to be regarded as having probably taken that function secondarily. Their morphological value remains unknown: functionally they may perhaps be brought into relation with the need of communication of the coelom and external water to equalize pressure in deep sea forms.

In many vertebrates the original function of the external nephric funnels, those opening into the large coelom as contrasted with the internal funnels opening into the Malpighian capsules, that is the passing out of water from the coelom, has been assumed more and more by the glomeruli and thus the external funnels have been abandoned as useless. Along with this loss of the coelom funnels there has been a loss of cilia in the tubules, in many forms, since

there was no longer need of other than the vascular pressure in the closed system of tubules and Malpighian capsules.

The venous system has undergone important changes in connection with the nephric organs. Thus the primitive net-work of veins passing from the pronephros to the heart becomes reduced to the two posterior cardinal veins as the pronephros degenerated, though remaining as segmentally arranged veins in the mesonephric region. Later the two fused posterior cardinal veins form with the remnants of the primitive sub-intestinal veins the median post cava.

In attempting a comparison of the vertebrate and any non-vertebrate we must consider *Amphioxus* as in many ways a primitive form. Thus in its urino-genital system the possession of nephric tubules throughout the branchial region is to be interpreted as a retention of the pronephros in a more anterior region than that it is now retained in amongst the Craniata; while the discharge of reproductive products has been changed from its primitive course through these tubules. If Boveri succeeds, as the author seems to think he will, in homologizing the peribranchial space of *Amphioxus* with the pronephric ducts, which are regarded as having an ectodermal connection, the unity of the nephric system in the Chordata would be demonstrated. At the same time the resemblance to the Annelid organs becomes very striking, yet as there can be no question of derivation of Chordata from real Annelids the author asks if this resemblance may not be a case of convergence.

On the same line that E. Meyer has imagined the Annelid's metamorphosis to have come from the segmentation of the reproductive tubes, Semon, while waiting for more light upon the value of the coelom, wonders if in the Chordata reproductive tubes may not have given rise to the mesoblastic somites, parts of which are still separated off as the Malpighian capsules with the old nephric tubules leading to the exterior, though now brought into use as parts of the excretory rather than reproductive passages.

Hermaphroditism the author thinks was not a primitive trait of the Chordata, but where occurring, as in other groups, is to be regarded as a remnant or re-occurrence of the original hermaphrodite nature of the reproductive gland in all Metazoa; such organs as the Müllerian duct in the male being transferred from the other sex; the inverse of what has taken place in the case of the mammary glands.

In connection with this work it is of interest to note that Hans Rabl<sup>1</sup> in a study of the adrenal bodies of birds derives the non-nervous

<sup>1</sup>Arch. f. mik. Anat. 33, 1891, p. 28. 3 pls.

part from the degenerating pronephric tubules, thus confirming Semon's view without a knowledge of Semon's full paper.

**Formation of the Germ Layers in an Ophiurid.**<sup>1</sup>—*Amphiura squamata* (Say) had been incompletely studied in 1870 by Metschnikoff who argued from analogy that there was here an invaginate gastrula though he did actually observe it. In 1882 Apostolides claimed that it was formed by delamination, but he gave no figures. Fewkes in 1887 confirmed this view but did not add much to its substantiation owing to lack of material.

In the present paper Russo considers the formation of the blastula, the entoderm and the mesoderm in this species.

Cleavage gives rise to a very characteristic blastula having elongated cells surrounding a rather small cleavage cavity.

The inner part of each cell is made very opaque by a quantity of pigment which is thought to be related to the presence of food-yolk: the outer part of each cell is yellow and transparent. The blastula thus looks like that of *Geryonia*.

The inner pigmented part of each cell becomes divided from the outer part and the resulting gastrula has an ectoderm of transparent, elongated cells with large nuclei and an entoderm of smaller, rounded, pigmented cells.

He thus extends the occurrence of delamination to a new group. Following Brouer he attributes this mode of gastrulation to the conditions of development. "Everywhere when a free-swimming blastula is present we find unipolar entoderm formation, corresponding to the direction of swimming: everywhere when development goes on in a limited space we find multipolarity." This the author thinks is true of the Echinoderms as well as of the Coelenterates.

The proctodoeum and the archenteron are formed by the breaking down at a definite point, first of the ectoderm and then of the entoderm. After this the mesoderm appears: first as a heap of irregularly shaped cells on either side of the proctodoeum. These cells arise by delamination from the ectoderm and, pushing backward, nearly fill the whole cleavage cavity. They finally arrange themselves upon the ectoderm and the entoderm, like an epithelium, thus forming a single cavity, the coelom.—G. W. FIELD.

**The Origin of the Sertoli's Cell.**—It is now generally known that the seminiferous tubules of a mammalian testis contain two funda-

<sup>1</sup>Achille Russo: Zool. Anz. Nov. 16, 1891.

mentally different kinds of cells; 1. The sperm-producing cells; 2. The sperm-nursing cell. The latter have been called Sertoli's cells by v. Ebner, in honor of the discoverer: they are also known as; spermatoblasts (v. Ebner); copulation cells; supporting cells; *Füsszellen*, *Stützzellen*; *cellules de soutien*, etc.

The sperm-producing cell is essentially migratory in habit and as soon as it attains a certain stage of growth it leaves the wall of the tubule and undergoes a manifold series of changes within the tubule.

In this respect the young sperm mother-cell offers a striking contrast to the young egg cell, which leads a sedentary life up to the last stage of maturity when it first becomes free by the rupture of the follicle.

The changes which the young spermatogonium undergoes after leaving the basement-membrane of the tubule are quite well understood. On the other hand, the history of the Sertoli's cell is not sufficiently known. The Sertoli's cell has a most characteristic appearance and is very easy to recognize by its comet shaped cytoplasm, by its large vesicular nucleus, and by its characteristic nucleolus. It is not likely that a single set of Sertoli's cells perform the nursing function for the several consecutive crops of spermatozoa. My conclusion, in regard to this point, as based on the study of human spermatogenesis, may be briefly stated as follows:—The sperm-nursing cell (the Sertoli's cell) in the seminiferous tubules of a mammal arises from a distinct anlage of its own, as the spermatozoan arises from the spermatogonium. In short, not only the two kinds of functional cells,—the sperm and its nurse—exist in the seminiferous tubule, but also the distinct antecedent cells for each of them; or more properly, the existence of two different kinds of cells in the functional seminiferous tubule is due to the existence of two entirely different kinds of antecedent cells. Just as the spermatogonia or the "Stammzellen" are the antecedent structure for the spermatozoa, so the small, stellate cells—*cellules étoilées* of Renson—found in the interstitial spaces of the spermatogonia are the antecedents of Sertoli's cells. The stellate cell stains quite differently from the adult Sertoli's cell, as the young spermatogonium stains differently from the adult spermatozoan. I have been able, however, to trace the series from the young stellate cell up to Sertoli's cell almost as completely as between the spermatogonium and the spermatozoan. The youngest spermatogonium stains quite differently from the youngest stellate cell, so that the difference between the two cells, the sperm and its nurse, begins extremely early. If they were derived from the same source, the differentiation in these

two directions must have taken place at the beginning of the embryonic history of the animal. My results therefore lend no support to the views in which Sertoli's cells are regarded as the modification of the sperm-producing cell proper or of its direct derivatives.

The differential staining was accomplished in a satisfactory manner by the use of two new aniline colors, viz: *Cyanine* and *Chromotrop*. *Erythrosine* has yielded also a very satisfactory result. The results of the application of these colors to the study of spermatogenesis and the differential staining of sexual cells after the manner of Auerbach, I shall report at no very distant future.—S. WATASE, Clark University, Worcester, Mass.

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## ENTOMOLOGY.<sup>1</sup>

**A Spider Enemy of *Oeneis semidea*.** — All butterflies seem to have enemies that prey upon them during some if not all stages of their existence, and *Oeneis semidea*, which lives on the top of our highest New England mountain, is no exception to the universal rule.

During a brief visit to Mt. Washington, N. H., during the summer of 1889 I was surprised while collecting on Semidea Plateau, as Mr. Scudder has very appropriately termed a favorite locality for this butterfly near the top of the mountain, to see great numbers of a dark bluish-black spider (*Pardosa albomaculata* Emerton) which seemed to be found everywhere, and was particularly noticeable along the carriage road leading from the lower end of this plateau to the summit. My first thought on seeing these spiders in such numbers was what were they doing at such an altitude, over 5000 feet; surely there were not sufficient flies at such an elevation to feed them, and in fact I saw none whatever; neither did I notice spider webs, and these would seem quite necessary were they feeding on flies. Therefore I took pains to learn, if possible, the reason of their being in that particular area and nowhere else observable on the mountain. I had noticed many dead and imperfect butterflies lying on the ground, especially along the roadway, but not suspecting the real cause, supposed they were killed by the passing of teams or exposure to the fierce cold winds which occasionally sweep across the mountain even in the summer time. It was not, however, until next to the last day of my stay on the summit that I discovered the true explanation for the great mortality among the butterflies and the presence of this peculiar spider.

<sup>1</sup>Edited by Prof. C. M. Weed, Hanover, N. H.